

Ch 14 Solutions + their behaviors

Ch 1 Review

Mixtures - Combination of sub where they retain chemical

Props. → separation

— Classifications

Types of Mixtures

① Solutions, ② Suspensions, ③ Colloids

separably
① Suspension → Largest Particles visible to naked eye.
↳ Ex Rocks in H₂O (settle out)

② Colloid → Medium size particles

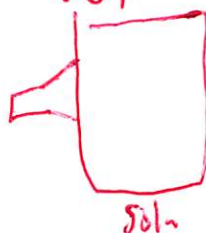
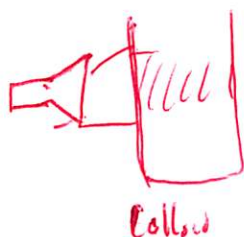
↳ always kept in suspension by molecules of solution.

↳ Milk, Mayo.

③ Particles are not visible to the naked eye.

Can be seen w/a flash light.

Tyndall effect. → Shine a light and beam reflects off particles.



③ ^{homogeneous} Solutions - mixture of smallest particles size (molecular) ²
No separate
↳ molecules, atoms, ions thoroughly dispersed

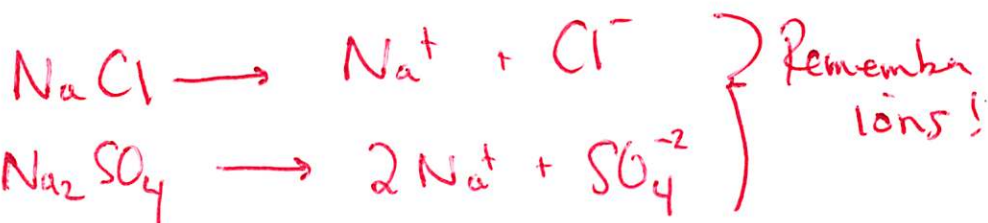
2 parts of solution

↳ Solute - gets dissolved

↳ solvent - does dissolving

When a substance dissolves in H_2O

↳ if ionic → separates into individual ions



↳ b/c positive charge → ~~ion~~ separate elec. current carried

Called electrolyte → sub diss in H_2O yield ~~soln~~ ^{conductive} soln.

if molecular → molecules separate

↳ if neutral → no conduction → ^{non} electrolyte.

Ch 14 Qs pg 410 3,4
419 Q1,3,5
425 Q2,3

p 435 Prob 1,2,6,8,10,12

436 15,18

App Q 1

p 437 App Prob 5

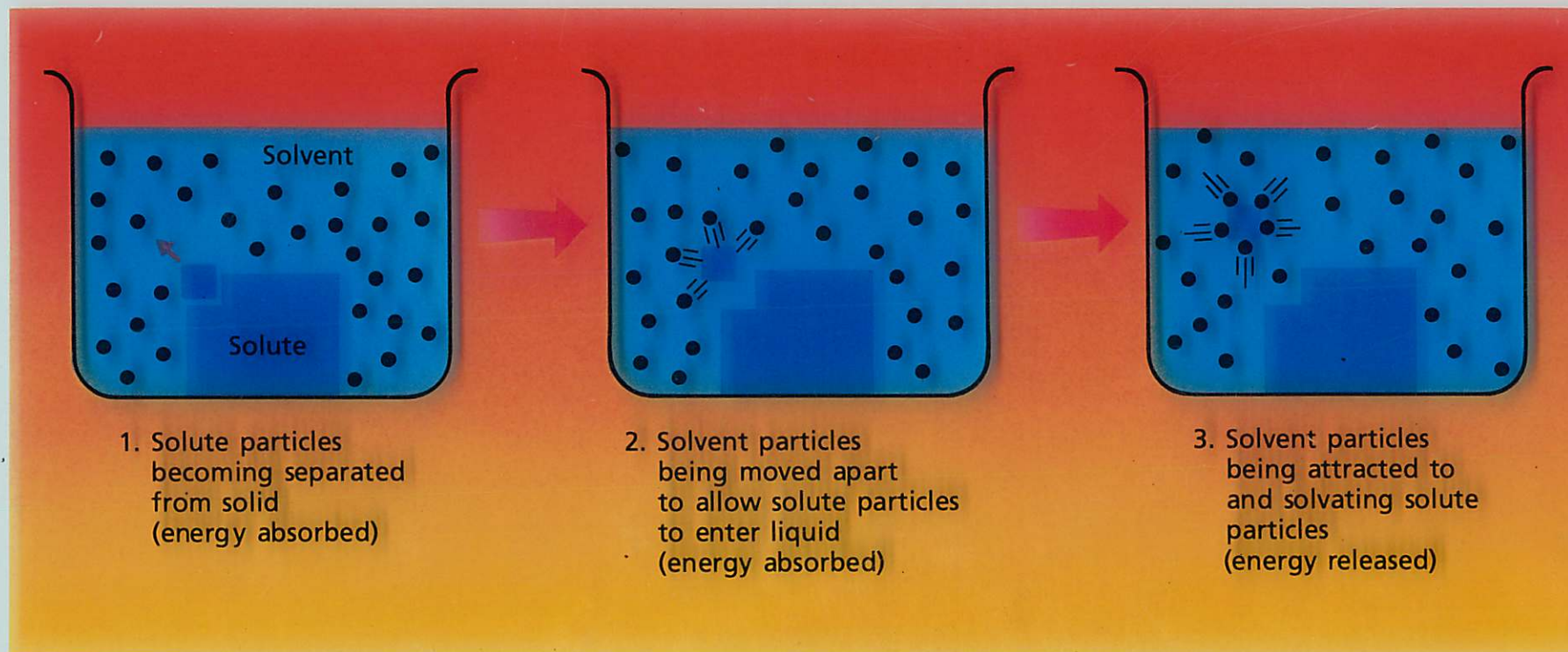
H
pg 434 Rev Conc 11
435, 13
Prob 4,5
436 Prob 10,14,17,22
24,29
437 29,34

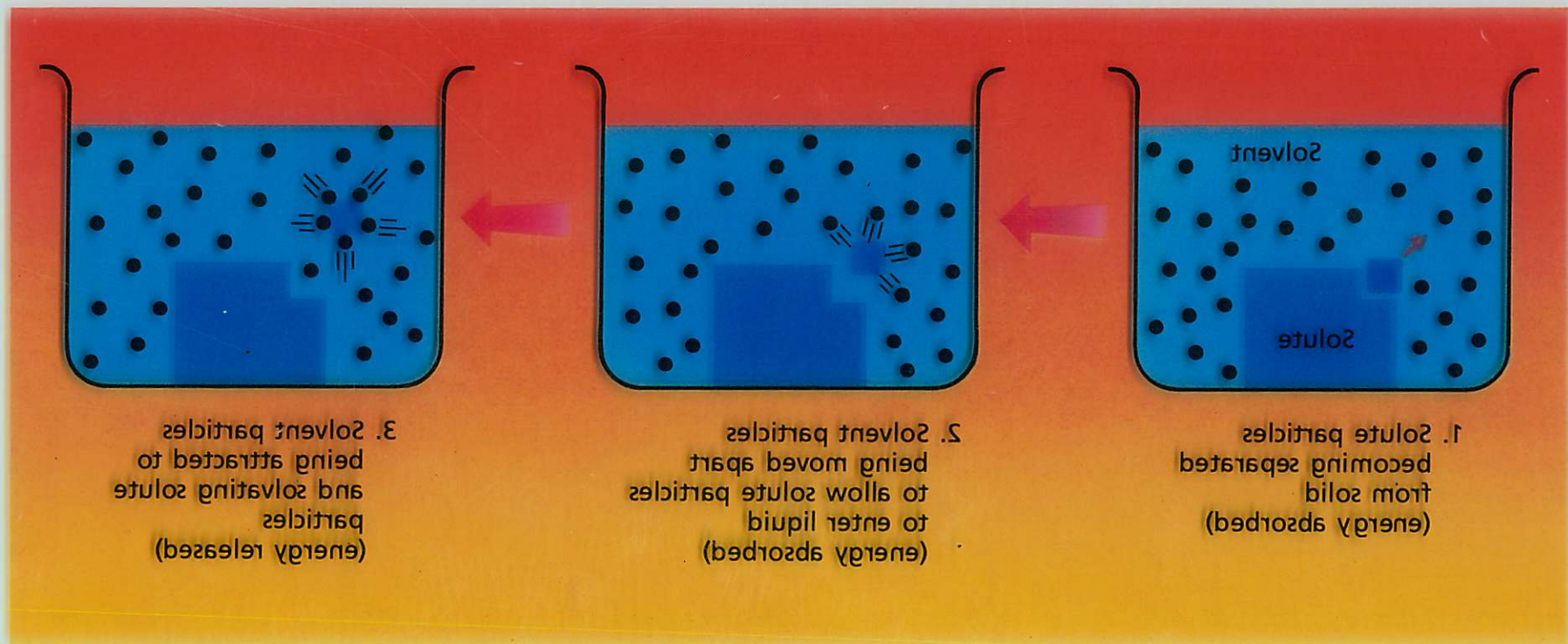
TABLE 14-5 HEATS OF SOLUTION (kJ/mol solute in 200 moles H_2O [(s) = solid, (l) = liquid, (g) = gas at STP])

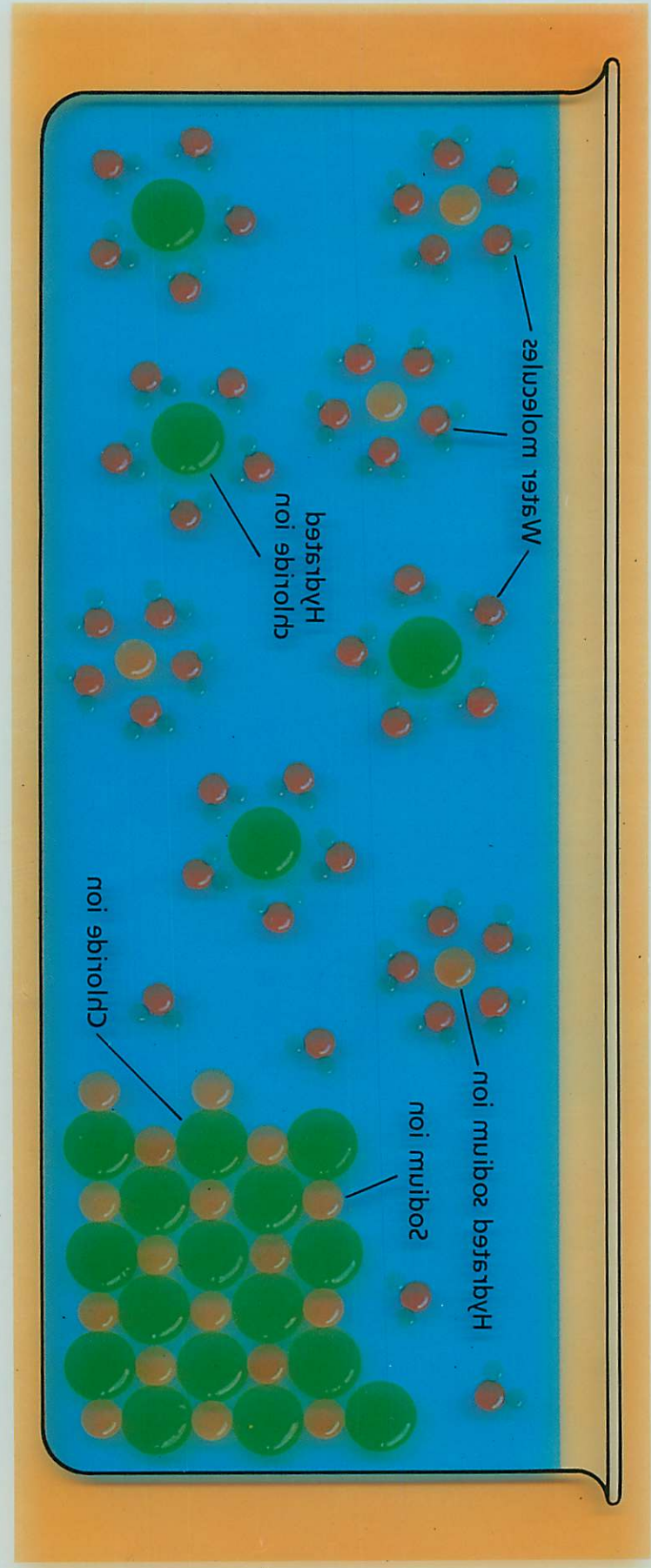
Substance	Heat of Solution	Substance	Heat of Solution
$\text{AgNO}_3(\text{s})$	+22.77	$\text{KOH}(\text{s})$	-54.59
$\text{CO}_2(\text{g})$	-19.91	$\text{LiCl}(\text{s})$	-35.0
$\text{CuSO}_4(\text{s})$	-67.81	$\text{Li}_2\text{CO}_3(\text{s})$	-12.8
$\text{CuSO}_4 \cdot 5\text{H}_2\text{O}(\text{s})$	+11.51	$\text{MgSO}_4 \cdot 7\text{H}_2\text{O}(\text{s})$	+15.9
$\text{HC}_2\text{H}_3\text{O}_2(\text{l})$	-1.59	$\text{NaCl}(\text{s})$	+4.27
$\text{HCl}(\text{g})$	-74.26	$\text{NaNO}_3(\text{s})$	+21.1
$\text{HI}(\text{g})$	-29.39	$\text{NaOH}(\text{s})$	-41.6
$\text{H}_2\text{SO}_4(\text{l})$	-74.30	$\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}(\text{s})$	+78.53
$\text{KCl}(\text{s})$	+17.58	$\text{NH}_3(\text{g})$	-34.7
$\text{KClO}_3(\text{s})$	+42.03	$\text{NH}_4\text{Cl}(\text{s})$	+16.2
$\text{KI}(\text{s})$	+21.4	$\text{NH}_4\text{NO}_3(\text{s})$	+25.5
$\text{KNO}_3(\text{s})$	+35.7		

TABLE 14-2 HEATS OF SOLUTION (kJ/mol solute in 500 moles H_2O [(s) = solid, (l) = liquid, (g) = gas at 25°C])

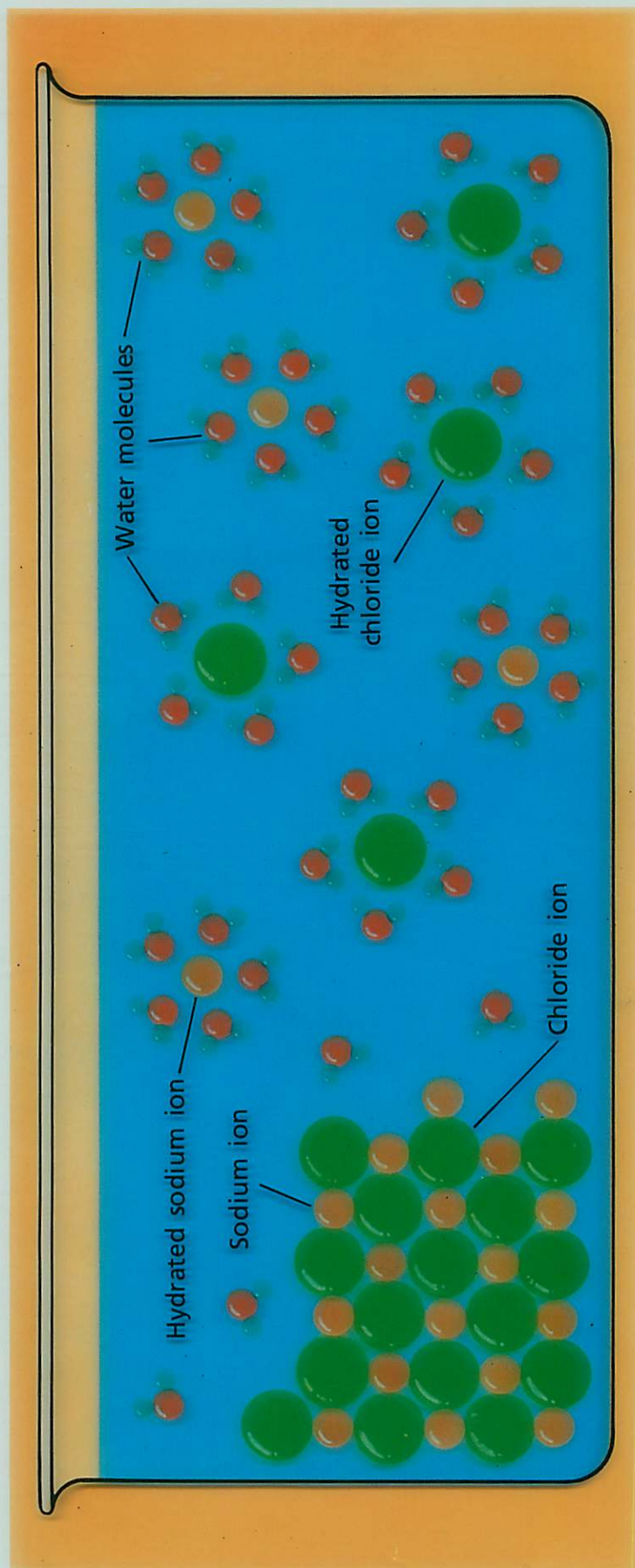
Substance	Heat of solution	Substance	Heat of solution
$KNO_3(s)$	+32.7	$NH_4NO_3(s)$	+52.2
$KI(s)$	+51.4	$NH_4Cl(s)$	+16.5
$KClO_3(s)$	+45.03	$NH_3(g)$	-34.7
$KCl(s)$	+17.28	$Na_2O \cdot 10H_2O(s)$	+78.23
$H_2SO_4(l)$	-74.30	$NaOH(s)$	-41.6
$HI(g)$	-29.39	$NaNO_3(s)$	+51.1
$HCl(g)$	-74.26	$NaCl(s)$	+4.27
$HC_2H_3O_2(l)$	-1.29	$MgO \cdot 7H_2O(s)$	+12.9
$CuSO_4 \cdot 5H_2O(s)$	+11.21	$Li_2CO_3(s)$	-15.8
$CuSO_4(s)$	-67.81	$LiCl(s)$	-32.0
$CO_2(g)$	-19.91	$KOH(s)$	-57.29
$AgNO_3(s)$	+22.77		







How does the hydration of NaCl affect the solution's conductivity?



Solutions take place in all phases

Gases - mixture of 2 gases, gas liquid, solid

Liquid - drink

Solid \rightarrow Alloy \rightarrow solid soln w/ metals

↳ Copper in nickel (nickel)

brass - (Copper + Zn)

Solution Process \rightarrow Sequester \rightarrow

Increase Rate of Solubility

for solubility

- ① increase surface area \rightarrow Break things up

- ② Agitation \rightarrow stir it

- ③ Heat solvent \rightarrow Increase KE to increase collisions between solvent + solute \rightarrow faster dispersion

Solubility - for every solute-solvent combination there is a limit to the amount of solute that can be dissolved.

↳ amount solute requires specific amount of solvent to make sat soln @ specific temp
when max amount of solute in solvent \rightarrow saturated soln

↳ If more solute added

Show overhead of soln process

41

Talk about energy involved

↳ must overcome $\left. \begin{array}{l} \text{solute-solute interactions} \\ \text{solvent-solvent interactions} \end{array} \right\} \text{Needs } E$

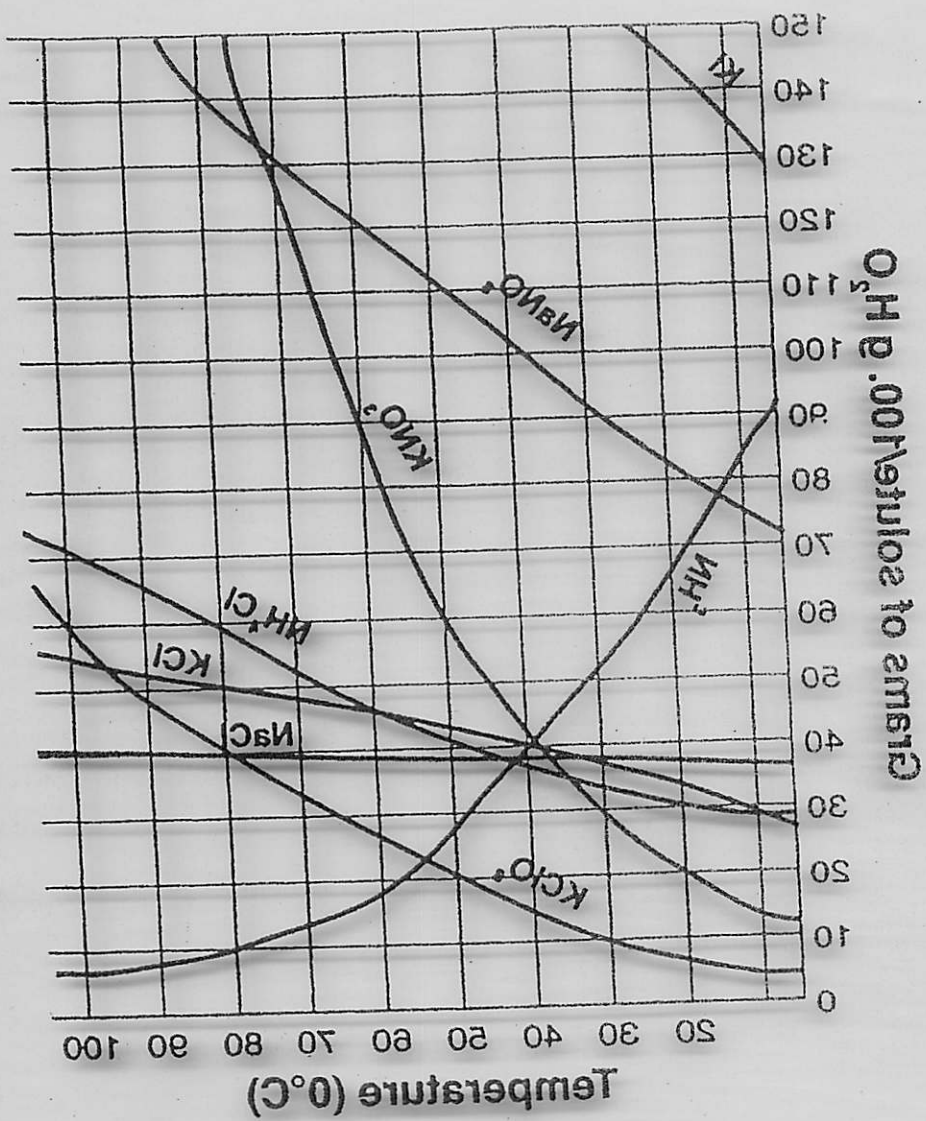
Solvent-solute interaction form - Release E

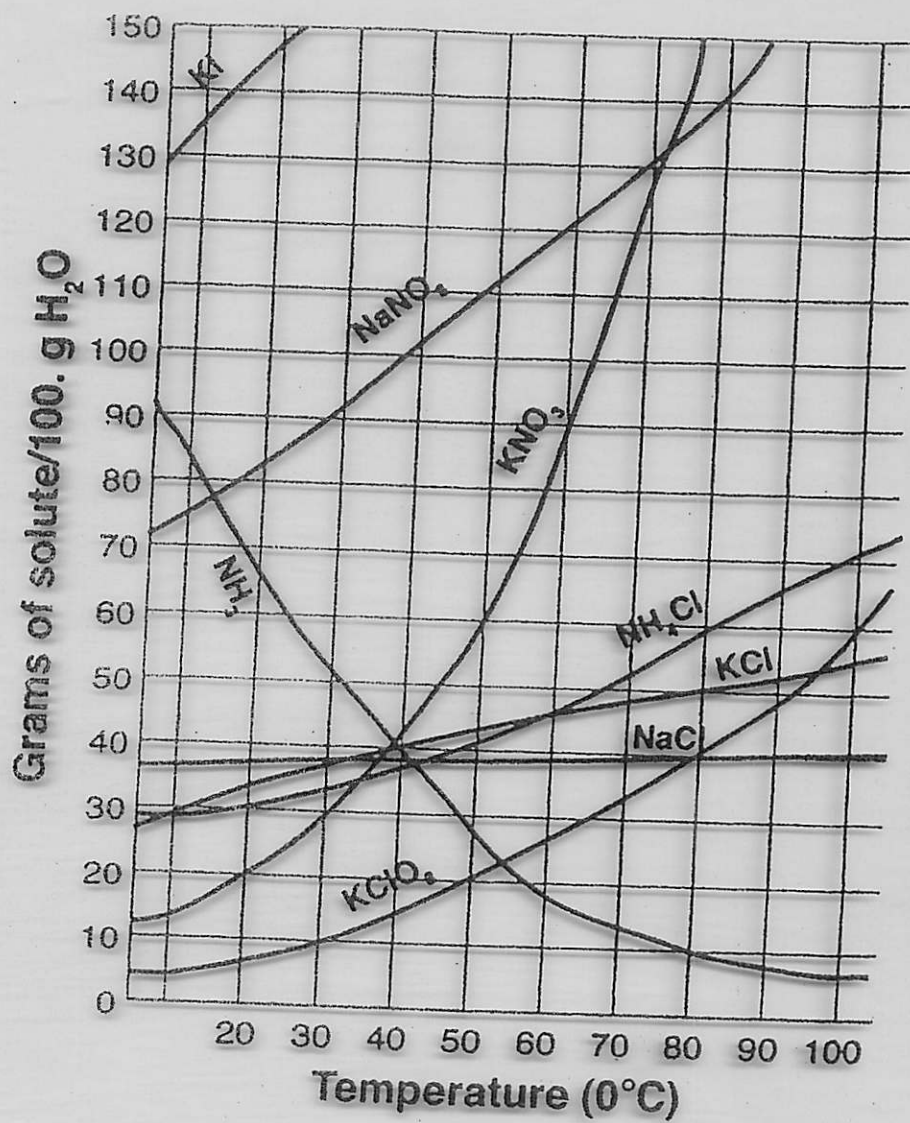
Also like dissolves like

↳ Tie into Equil.

↳ take away solute \rightarrow equil shifts

↳ tie into heat to shift of equil





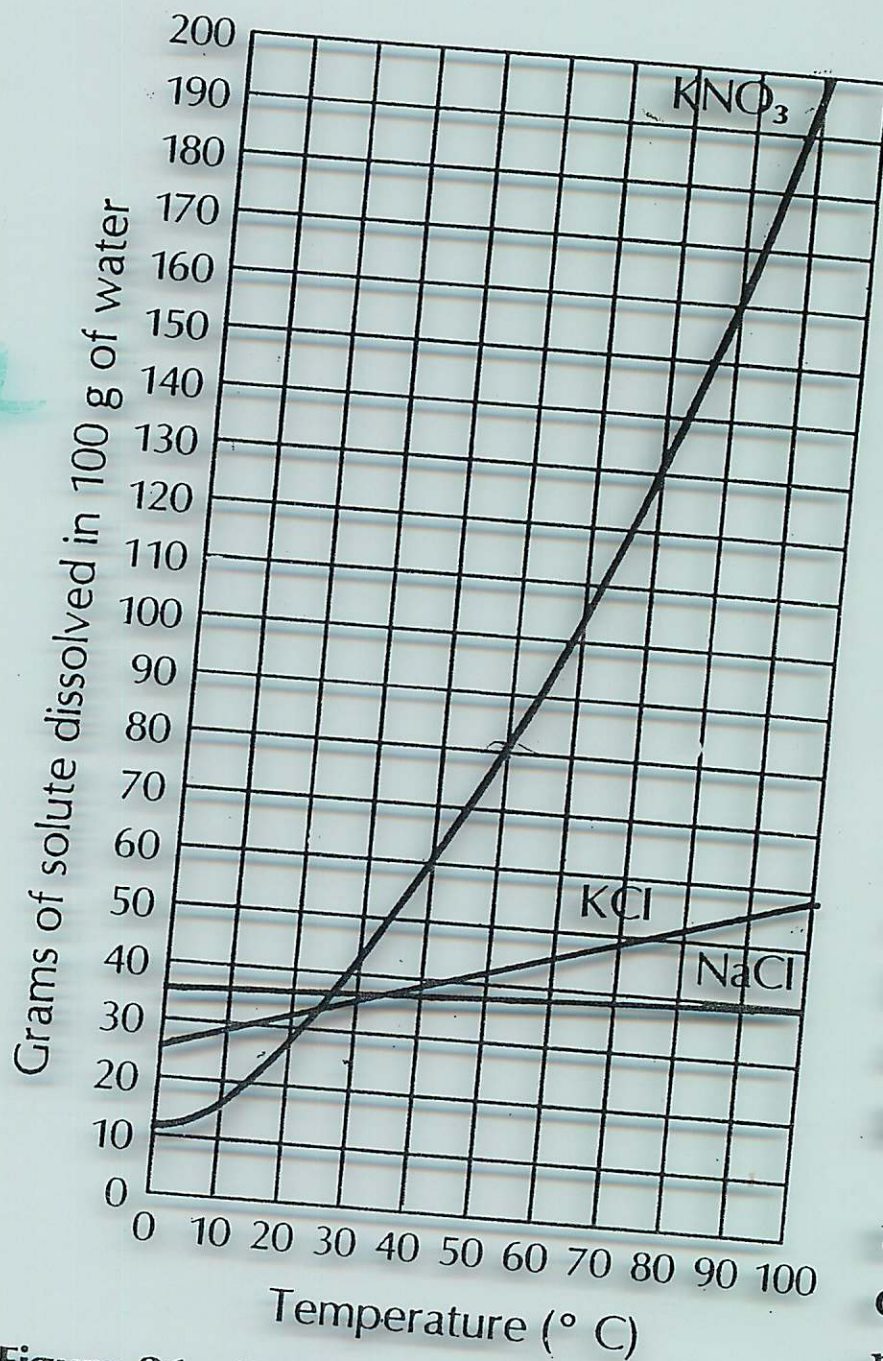
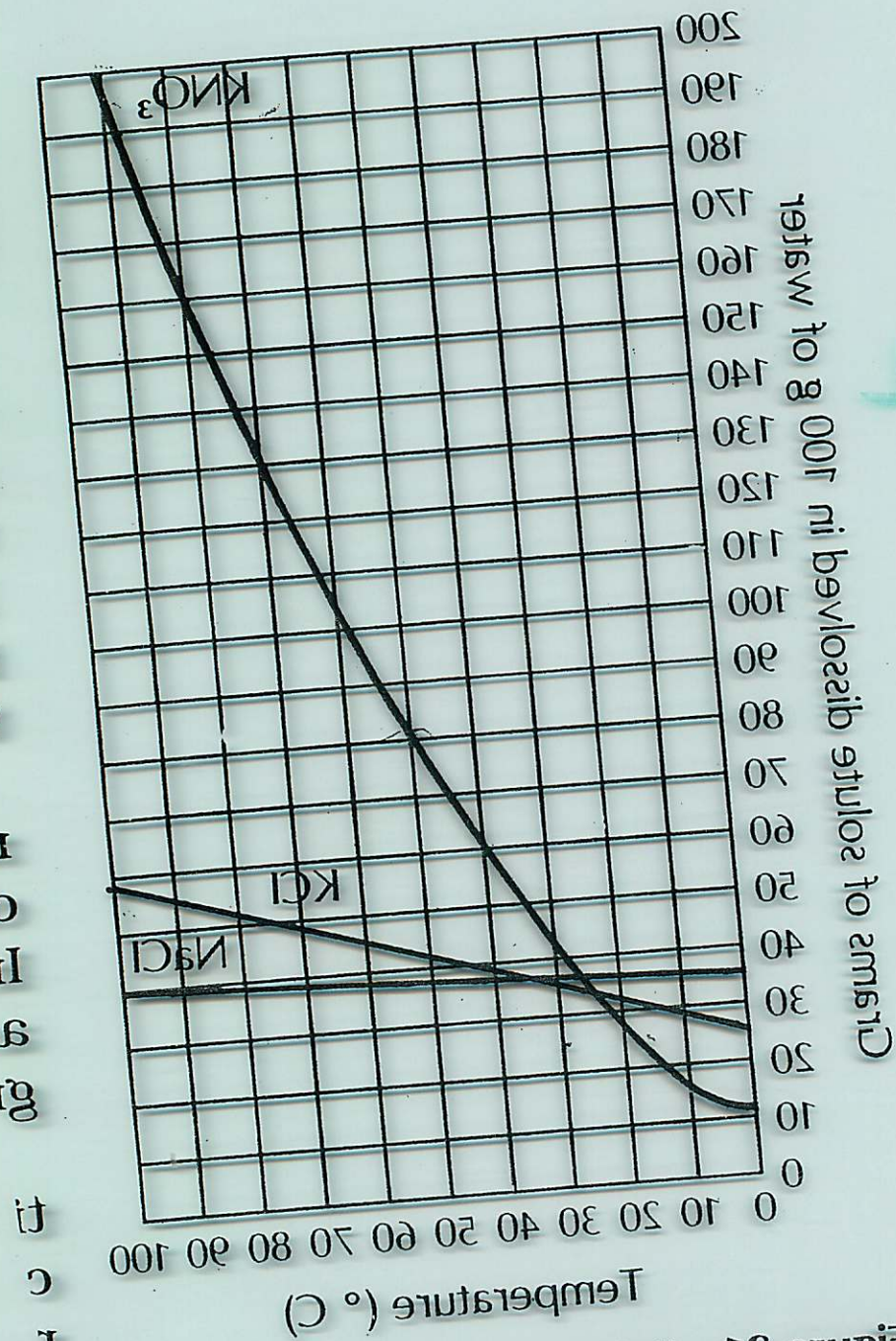


Figure 21 Relationship between solubility in water and temperature.

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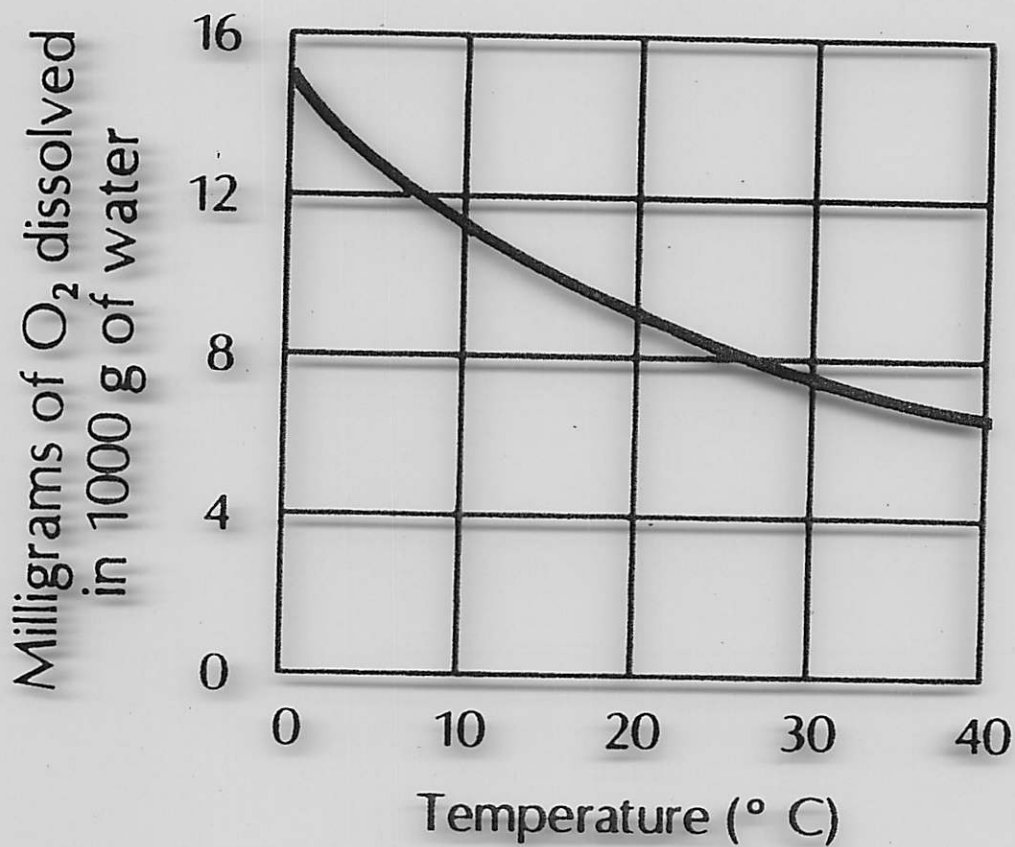


Figure 22 Solubility curve for O₂ gas in water in contact with air.

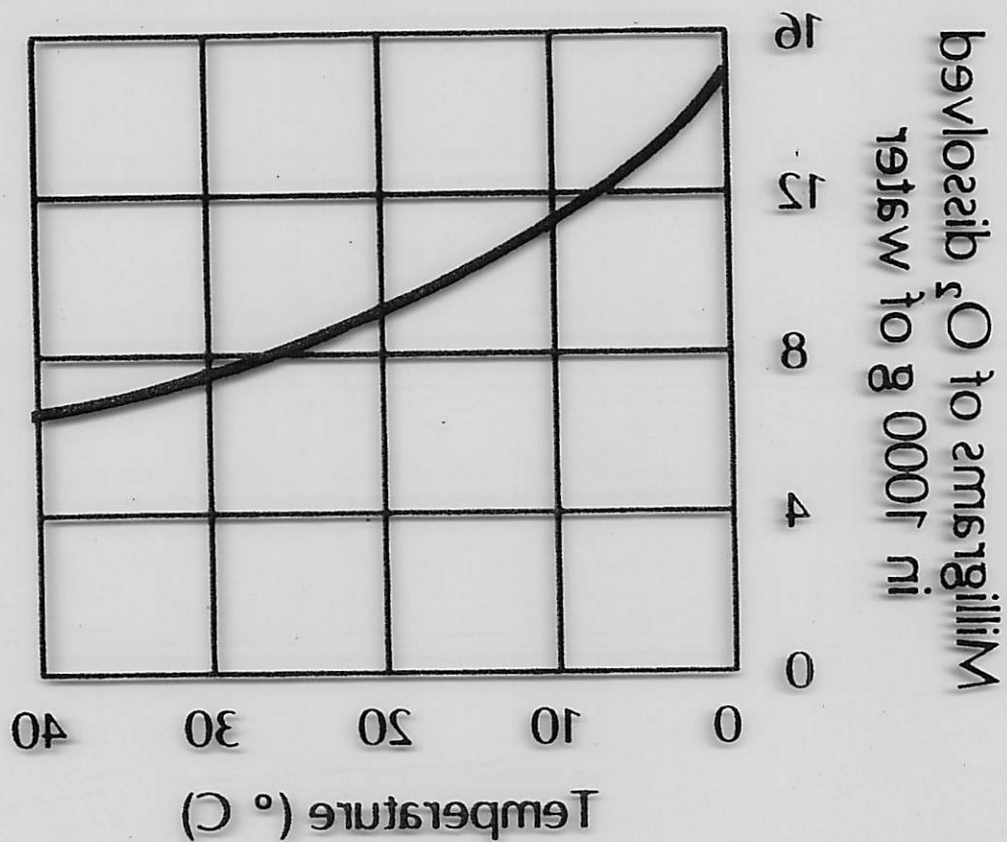


Figure 22 Solubility curve for O₂ gas in water in contact with air.

Solubility Curves

for Solids

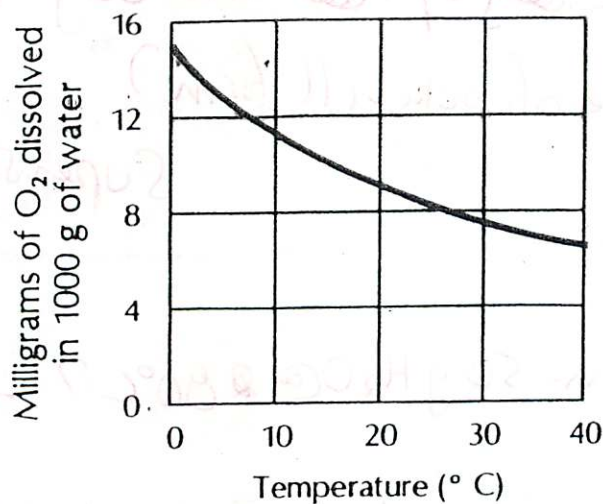
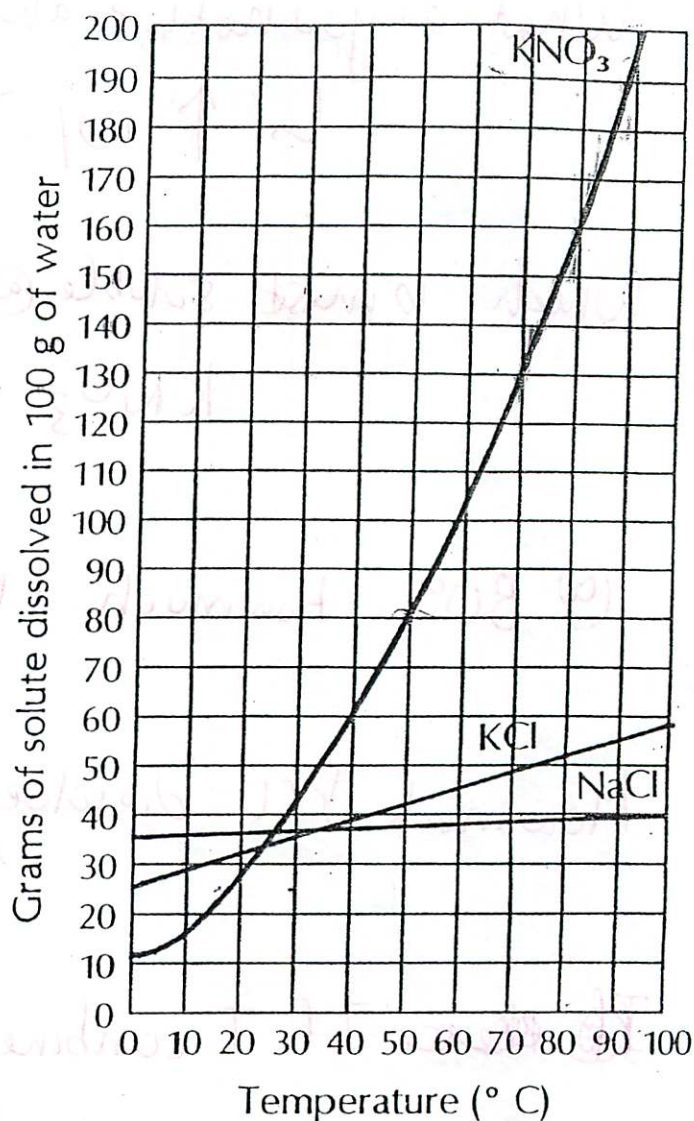


Figure 22 Solubility curve for O₂ gas in water in contact with air.

Figure 21 Relationship between solubility in water and temperature.

← for gases

What do you notice about Solubility vs. Temp?
↳ ↑ w/ Temp

Which is ~~most~~ soluble @ 80°C ? least?
 KNO_3 NaCl

@ 80°C How much KNO_3 dissolves in $100\text{g H}_2\text{O}$?
↳ 160g

How much KCl dissolves ^{in $100\text{g H}_2\text{O}$} @ 50°C ?
↳ 42g

~~The~~ ~~these~~ If I combine ^{100g} ~~80g~~ of ^{H_2O} ~~H_2O~~ and 80g of NaCl
@ 90°C what type of soln will form?
Supersat.

Hande

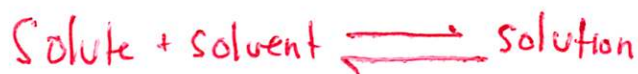
How much KNO_3 dissolves in $50\text{g H}_2\text{O}$ @ 80°C ? → 80g

If a saturated soln of ^{KCl} ~~KNO_3~~ cools from 70°C to 10°C how much will ppt? → $\sim 23\text{g}$

In a saturated solution

↳ There is a max amount of solute dissolved

The rest of the solute remains as solid in bottom of container



but collisions are occurring here too

some solute going into solution some coming out

@ equal rates

Equilibrium \rightarrow dissolving + crystallizing occur @ equal rates
Le Chatelier's Principle

What effects solubility (not confused w/ Rate)

Types of solutes + solvents - oil & water don't mix

↳ NaCl in H₂O but not oil?

Rule of thumb \rightarrow "like dissolves like"

Water \rightarrow polar molecule \rightarrow dissolves polar things + charged things

↳ H-bonds, sep of charge

why salts + sugars dissolve

Non polar molecules \rightarrow no H-bonds

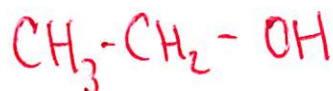
Ex $\text{CCl}_4 \rightarrow$ nonpolar - H_2O , salt can't dissolve

\hookrightarrow does dissolve non polar compounds \rightarrow fats, oils, grease

Voc miscible \rightarrow 2 subs are soluble in all combinations

Immiscible \rightarrow subs are not soluble

look @ Ethanol



1. in H_2O - soluble b/c OH
miscible

2. as solvent for salt - poor
b/c non polar region

3. use for not polar v. good b/c non polar
4

Pressure - P change v. little effect on solids + liq
but do effect gas

Eq \rightarrow gas + solvent \rightleftharpoons soln

If CO_2 P \uparrow - solubility \uparrow

Carbonation industry

Temperature

for solids $\rightarrow T \uparrow$ solubility \uparrow

\hookrightarrow but different for each see curve.

for gases $\rightarrow T \uparrow$ solubility \downarrow b/c

$T \uparrow$ KE \uparrow $V \uparrow \rightarrow$ leave soln. wkshrou curves

14.3 [] of Soln - measurement of amount of solute in a given amount solute.

3 way % , M , m } gives different amounts
not general like con. dil

$$\% \rightarrow \frac{\text{mass solute}}{\text{mass solute} + \text{mass solvent}} \times 100\%.$$

by mass

Must be sum of masses \uparrow

Molarity - # of moles in 1 L of soln.

$$\hookrightarrow M = \frac{\# \text{ of mol}}{\# L} = \text{mol/L}$$

} good for
getting # of moles
of soln.

H supplement

very useful to know

↳ Talk about dilutions

In a lab situation dilutions are imperative. Why make several solutions when can dilute a stock.

Trick is → $M_1 V_1 = M_2 V_2$
have need.

~~mol/L~~

What volume of a 12.0 M stock of HCl is needed to make 100ml of a 0.100 M HCl soln? How much H₂O?

$$M_1 = 12.0 \text{ M HCl}$$

$$V_1 = ?$$

$$M_2 = 0.100 \text{ M}$$

$$V_2 = 0.100 \text{ L}$$

$$a \quad V_1 = \frac{M_2 V_2}{M_1} = \frac{(0.100 \text{ M})(0.100 \text{ L})}{12.0 \text{ M}} = 8.33 \times 10^{-4} \text{ L}$$

$$= 0.813 \text{ ml}$$

$$= 813 \mu\text{l}$$

b 99.187 L of H₂O needed

H supplement Ch 13.3 Changes of State (Must Do Before Colligative Properties)

Before discussion of effect of [solute] on BP + FP
need to discuss basic changes of state

pg 387

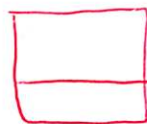
~~Before~~ Before we get into Boiling + Freezing we need to go back
to Equilibrium -

→ Equilibrium + Vapor P.

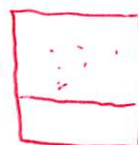
↳ Eq. → dynamic condition where 2 opposing physical or chem. processes occur @ equal rates in a closed system

Remember Sat. Soln (will do chemical Rxn @ end of year)
also chemical Rxn $H_2(g) + I_2(g) \rightarrow 2HI(g)$

→ In changes of state → consider liquid w/ vacuum
vaporization takes place first then
[vapor] reaches a critical pt where vaporization
+ condensation occur @ equal rates



↓



liquid + heat \rightleftharpoons vapor

low VP → non volatile liq → (slow) b/c attractions of molecules
(molten ionic) (H_2O)

1888 Henri Louis LeChâtelier → principle that allows scientists to predict how sys. @ equilibrium will respond to environmental Δ 's

LeChâtelier's Principle → when system @ eq is disturbed by app of a stress (Δ in E , P or T) it attains a new equilibrium to minimize the stress

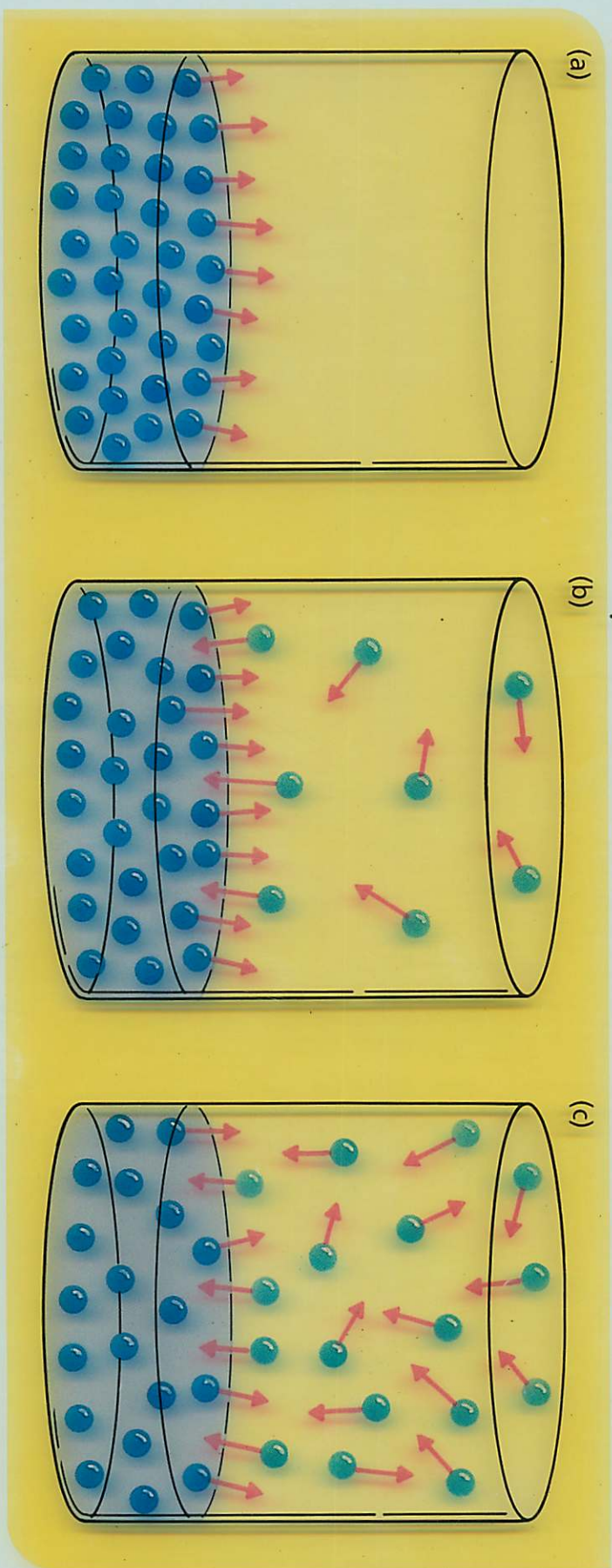
How will $VP \Delta$ if $T \uparrow$?? Forward Rxn favored or V , or $P \Delta$

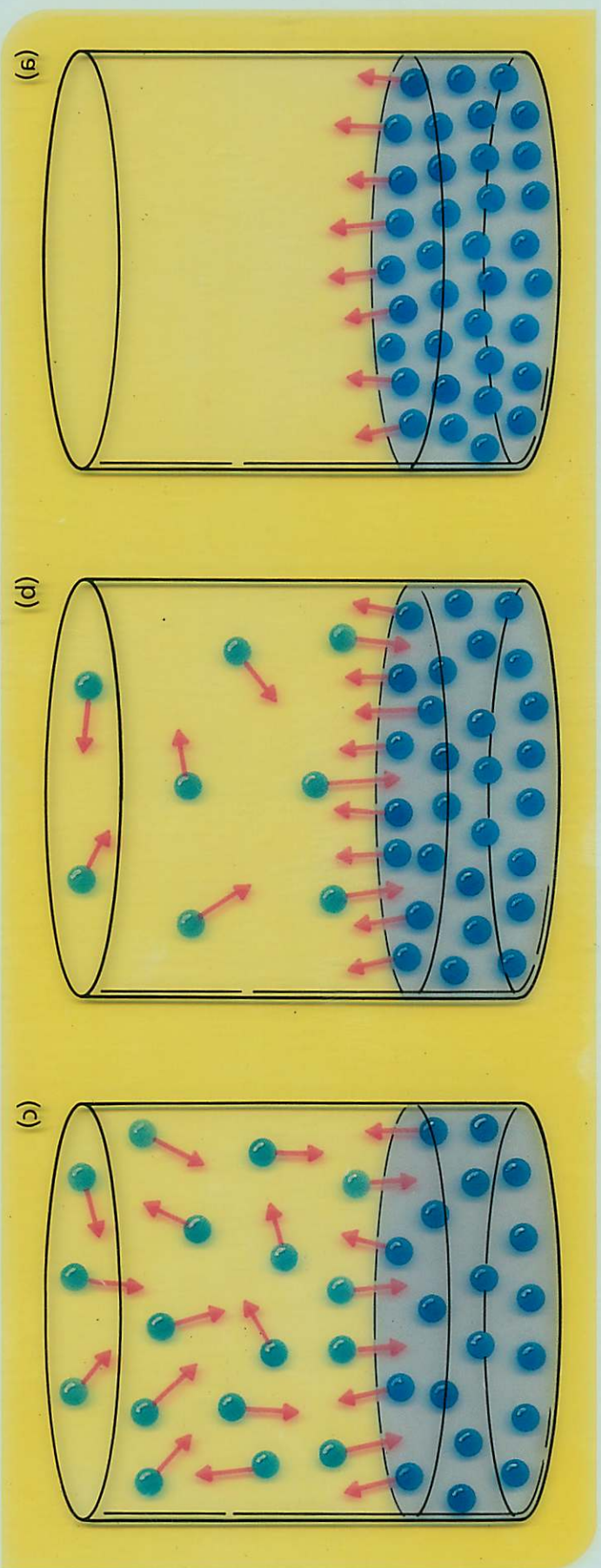
Eq. $VP \rightarrow$ P exerted by Vapor which are in eq w/ liquid @ given T

Show graph → Explain that Ea. $VP \uparrow$ w/ T
(closed system (pressure cooker)!!)

high $VP \rightarrow$ Volatile liq - (evaporate fast) ether.
↳ b/c weak attractive forces

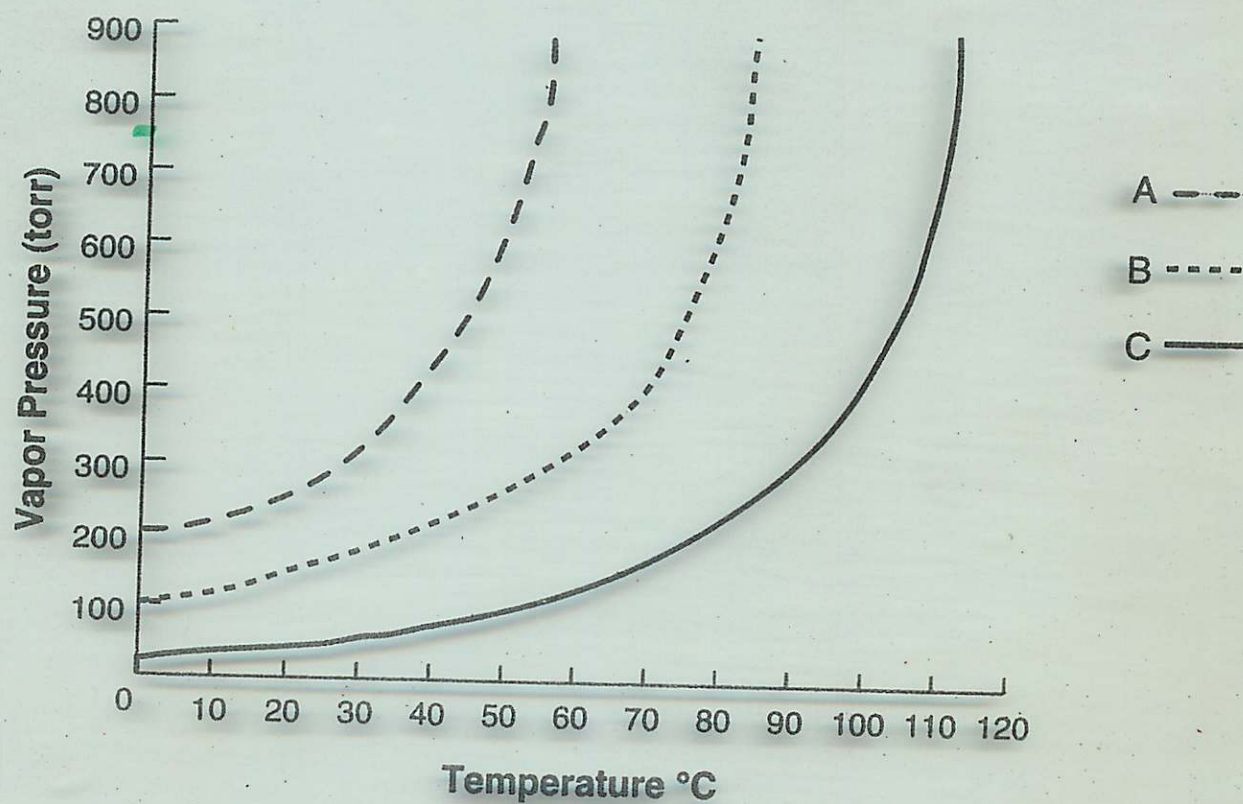
low $VP \rightarrow$ non volatile liq \rightarrow (slow) b/c attraction of molecules
(molten ionic) (H_2O)





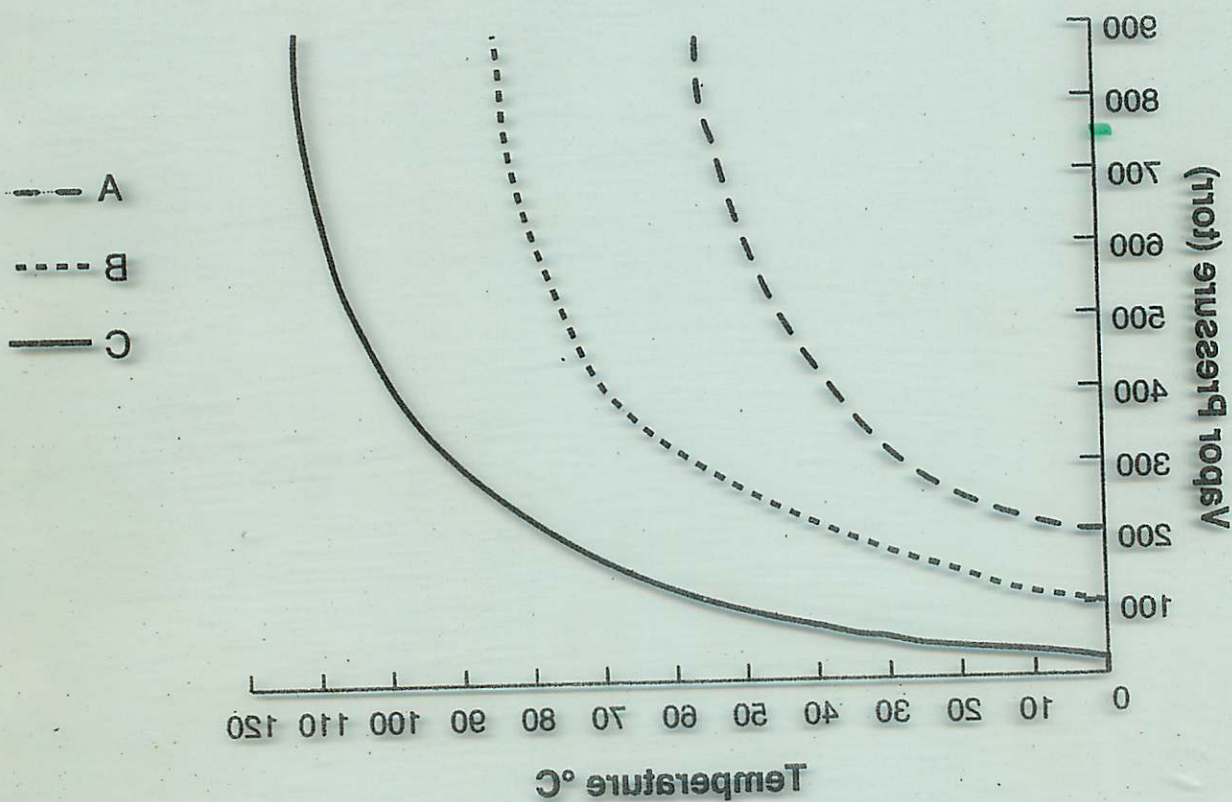
VAPOR PRESSURE AND BOILING

A liquid will boil when its vapor pressure equals atmospheric pressure. Answer the questions following the graph.



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Boiling \rightarrow liquid to vapor

\hookrightarrow in liquid and at surface when EVP is = to Atmospheric P

\hookrightarrow So as $T \uparrow$ $EVP \uparrow$ and Boiling takes place

lower atmospheric P (high elevation) lower BP

(Example w/ vacuum pump)

Freezing/Melting (Same temp)

\hookrightarrow liquid to solid

FP \rightarrow temp @ which solid + liq are @ Eq. @ latn

Subliming \rightarrow solid to liquid.

Quick

Definition

Bk no need
for Description

VP not
necessary

Phase Diagrams \rightarrow graph of T vs P that indicates when a 3 phases
of a substance exists

Tripb $P_t \rightarrow T + P$ @ which solid + liq + gas coexist

~~$T_c =$ Critical point @ which~~

Critical pt $\rightarrow T(t_c) + P(P_c)$ @ which a substance
cannot exist as a liquid.

p 390 Q3 p 397 Q12

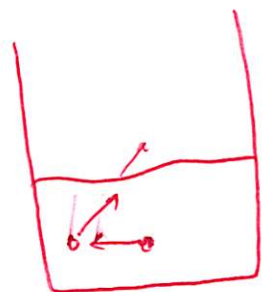
$$\text{Molality} = \frac{\text{moles solute}}{\text{Kg solvent}} = m \quad \left. \begin{array}{l} \text{useful b/c} \\ \text{doesn't change w/ temp} \\ \text{\% too} \end{array} \right\}$$

Colligative Properties

↳ property that depends on amount of solute particles (independent of nature of particles)

Freezing point depression + ~~vapor pressure~~ ^{freezing point} Boiling point elevation
depend on ~~BP~~ Vapor pressure Lowering

Vapor P → ~~BP~~ P caused by molecules that escaped into gas phase from liquid



sometimes escape into gas phase.

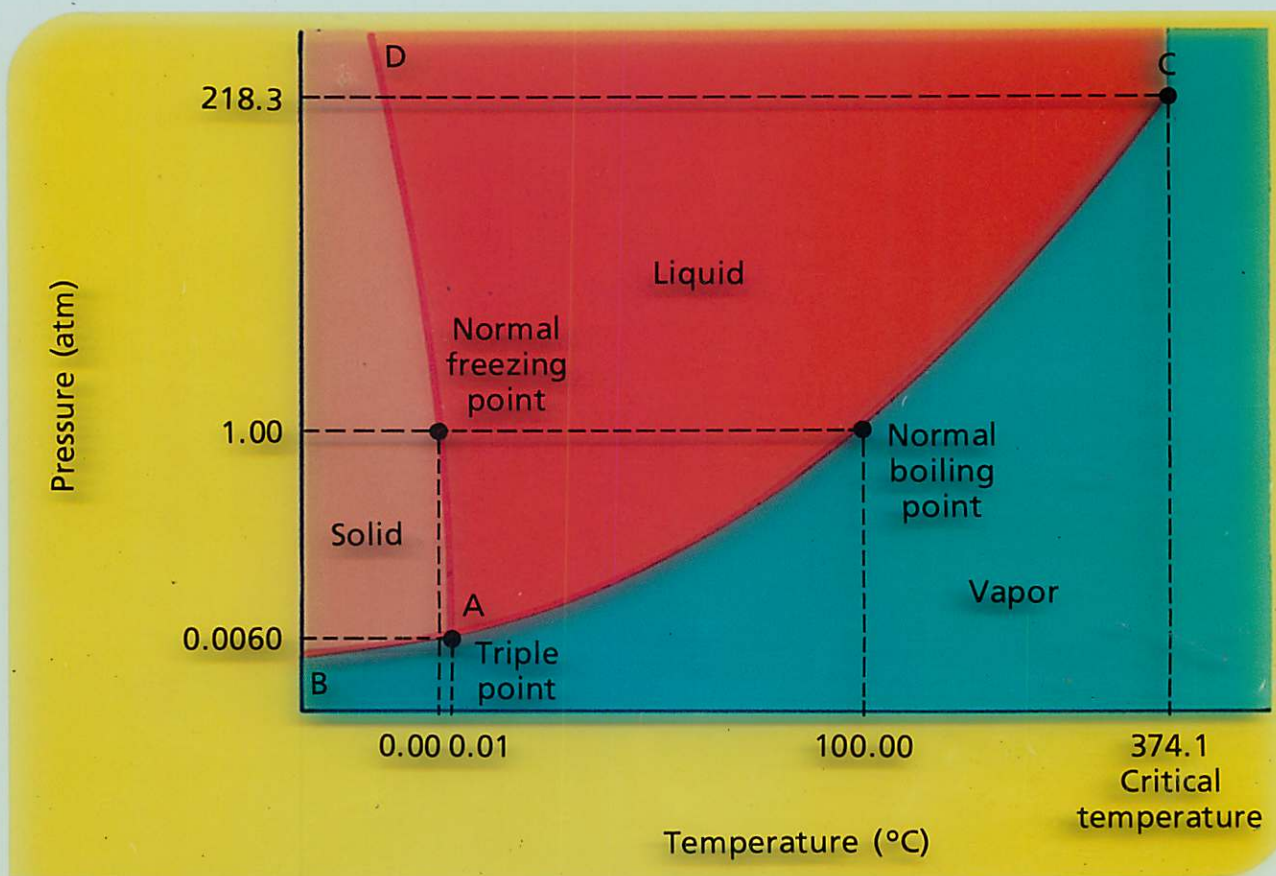
this vapor exerts a pressure on liquid surface
in a closed system it reaches an equilibrium.

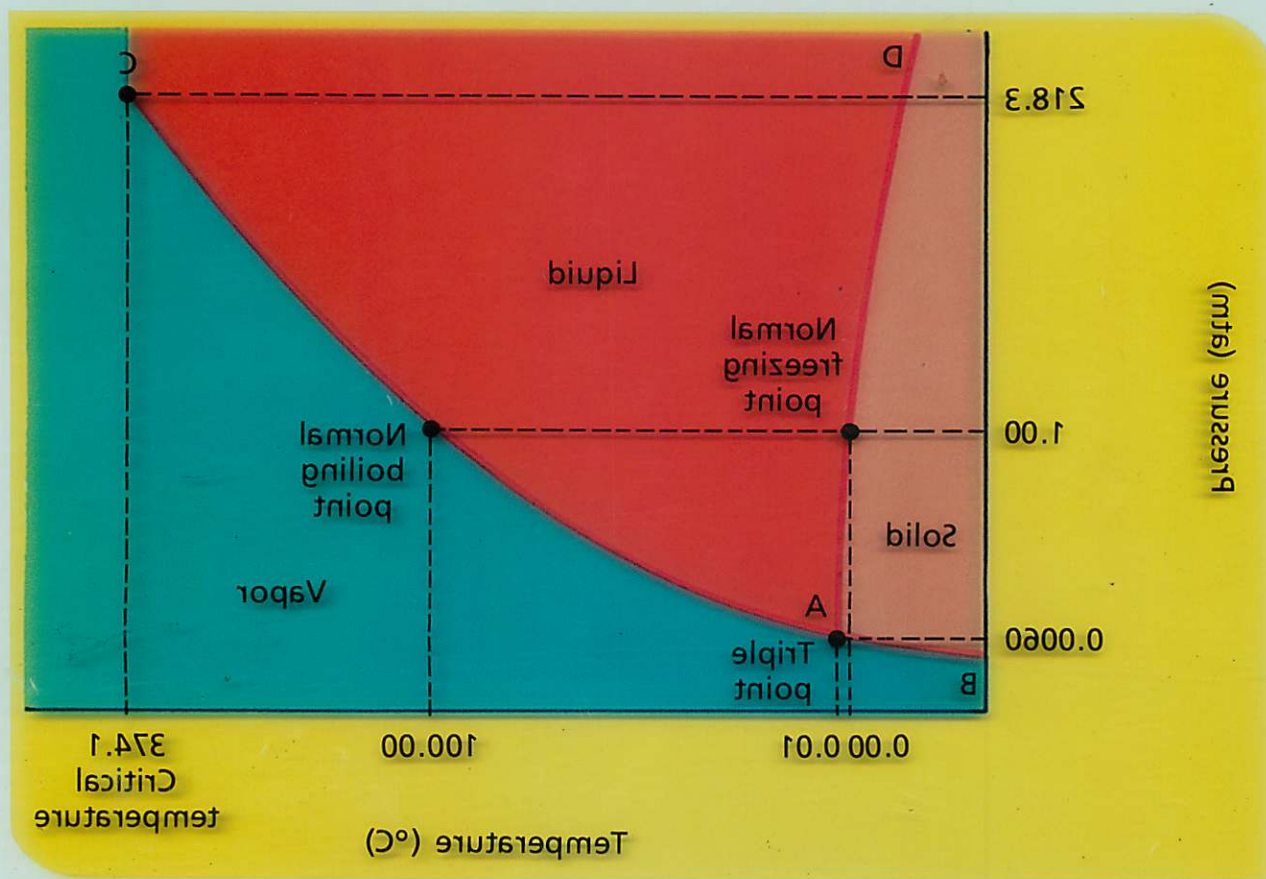
open system → molecules escape — evaporation.

high V.P. → low BP, molecules volatile (evaporate easily)

low V.P. → high BP, nonvolatile

Remove P (Vacuum) H₂O boils @ low T to
Stabilize Vapor Press





When solute added liquid remains

liquid over larger ΔT range. Show overhead

Does not matter which solute

Solutions are given in molality

b/c molality $\Delta w/T$

Freezing Point Depression (Antifreeze)

↳ lower vapor P. \rightarrow lower f.p.

for water \rightarrow a 1m soln has a decreased FP of -1.86 .
 $-1.86^\circ\text{C}/m \rightarrow K_f$ (molal fp const)

every liquid has its own one p429

To find fp depression

$$\Delta t_f = K_f m$$

will be given original normal fp ^{2 examples}

Boiling Point $\rightarrow T$ @ which V.P of liquid = Atmospheric P

\uparrow

change either, change BP

add solute takes more E to release ~~solute~~ solvent
~~particle~~

for H_2O 1m soln elevates H_2O to $0.51^\circ C$ $T = 100.51^\circ C$

$$K_b = \frac{0.51^\circ C}{m} \text{ or } \frac{0.51^\circ C \cdot 1 \text{ kg solvent}}{\text{mol solute}}$$

find BP elevation $\Delta t_b = K_b \times m$

Do a problem

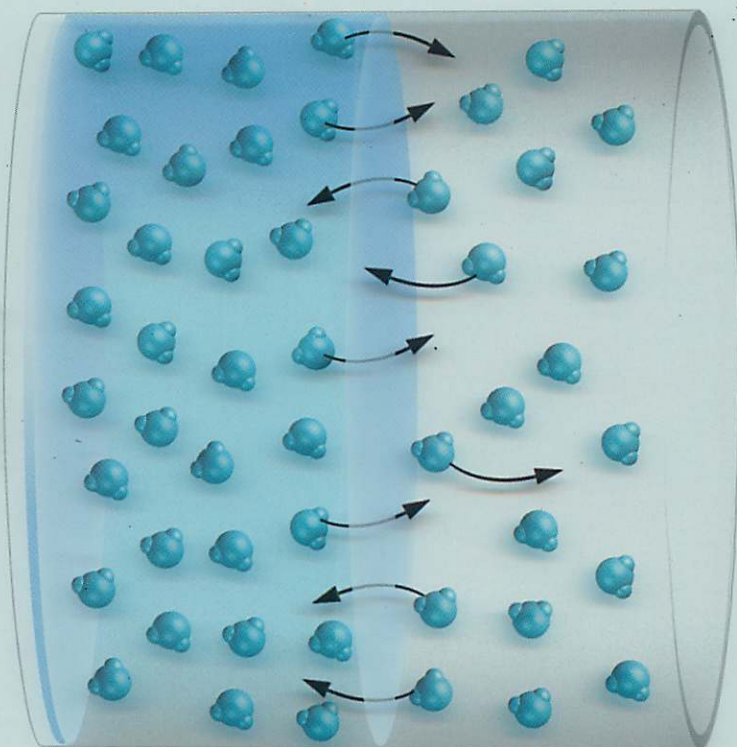
end.

Make worksheet.

H \rightarrow Need to talk about Ionic Solutes
 \hookrightarrow need to get mol of ions!

Vapor Pressures of Pure Water and a Water Solution

The vapor pressure of water over pure water is greater than the vapor pressure of water over an aqueous solution containing a nonvolatile solute.

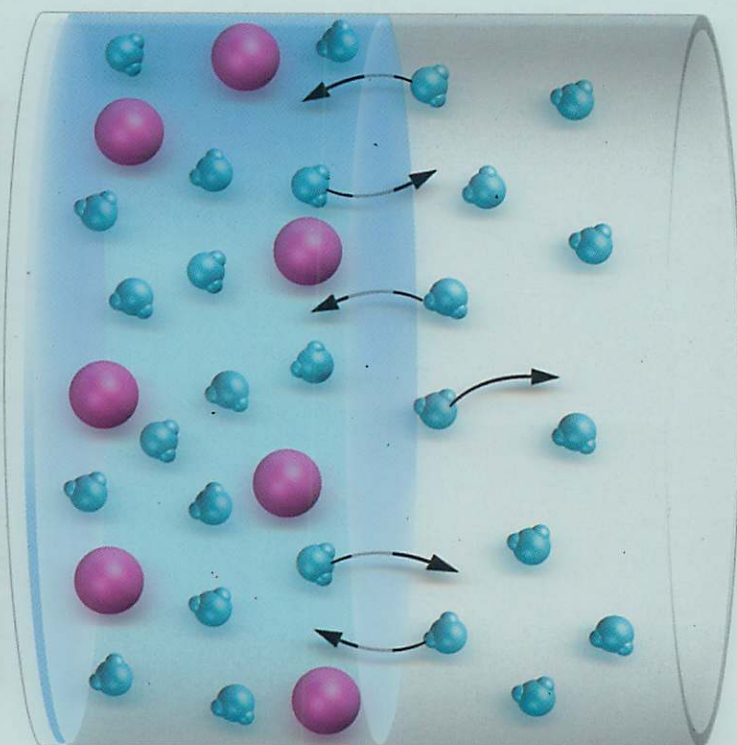


Pure water



Used to represent $C_{12}H_{22}O_{11}$, sucrose

Used to represent H_2O , water



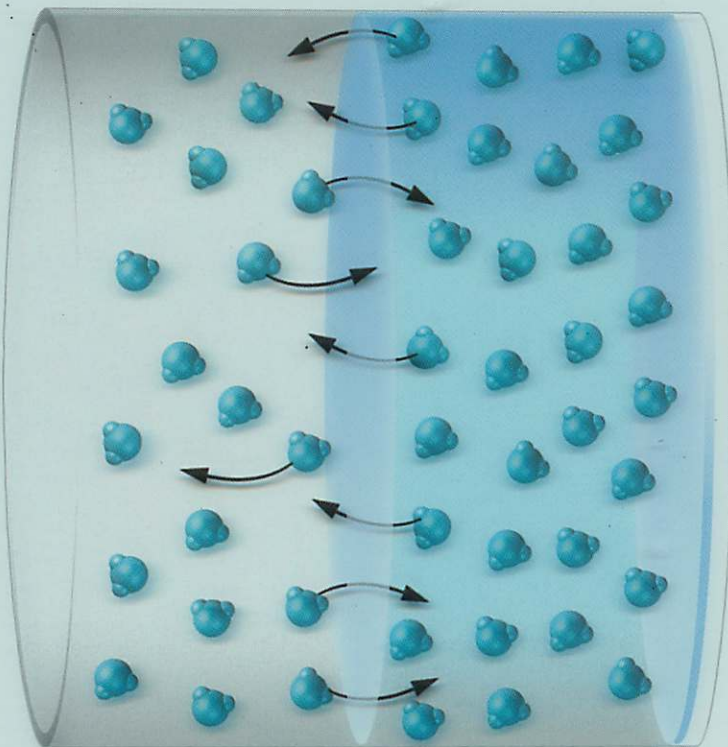
Aqueous solution of nonvolatile solute



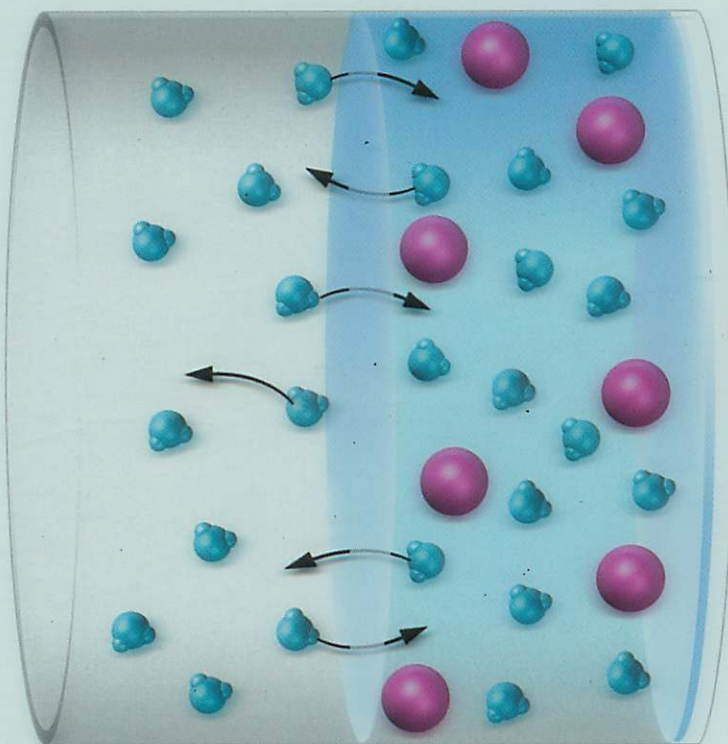
Used to represent H_2O , water

Used to represent $\text{C}_{12}\text{H}_{22}\text{O}_{11}$, sucrose

pure water



Aqueous solution of nonvolatile solute



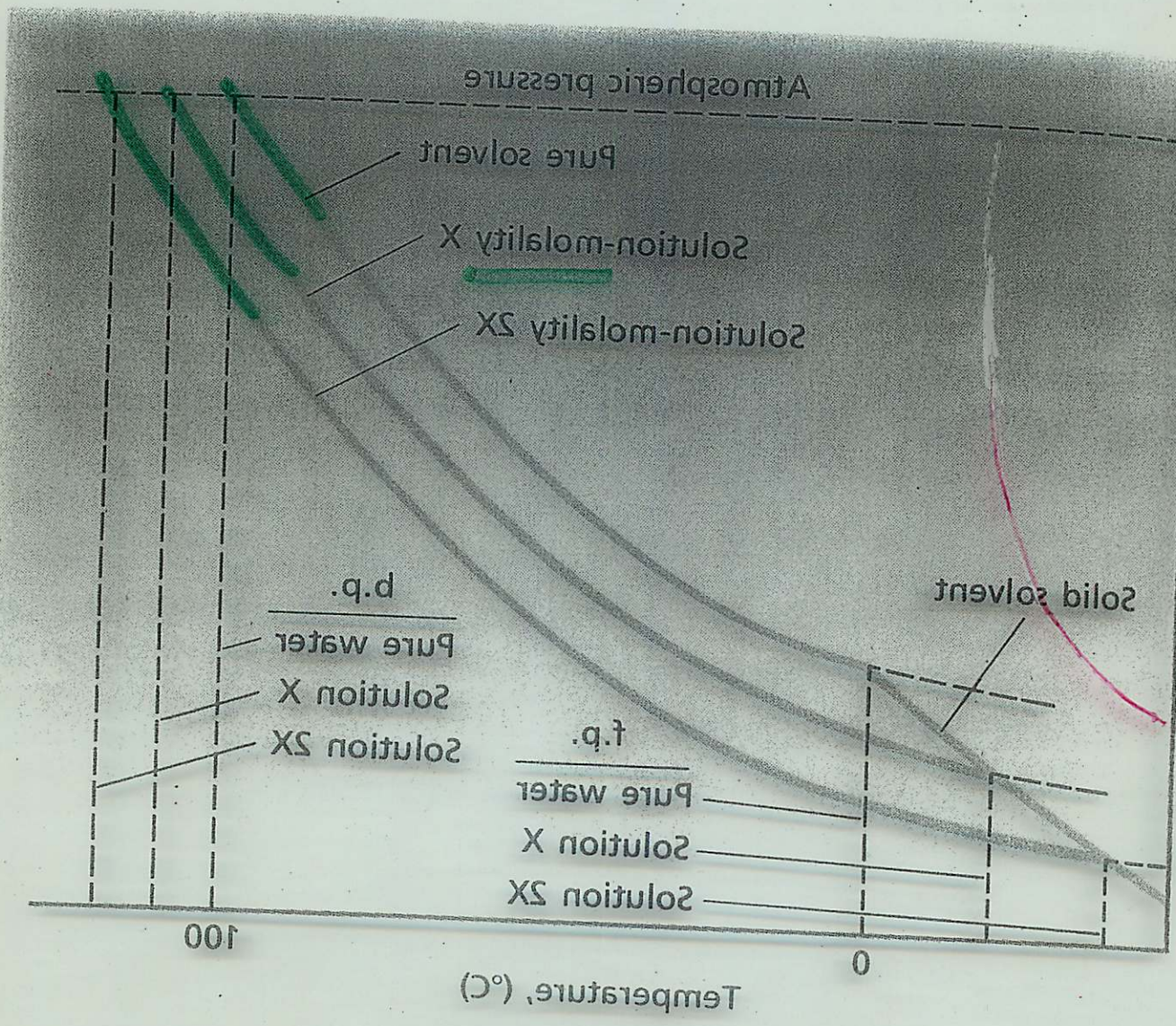
aqueous solution containing a nonvolatile solute.

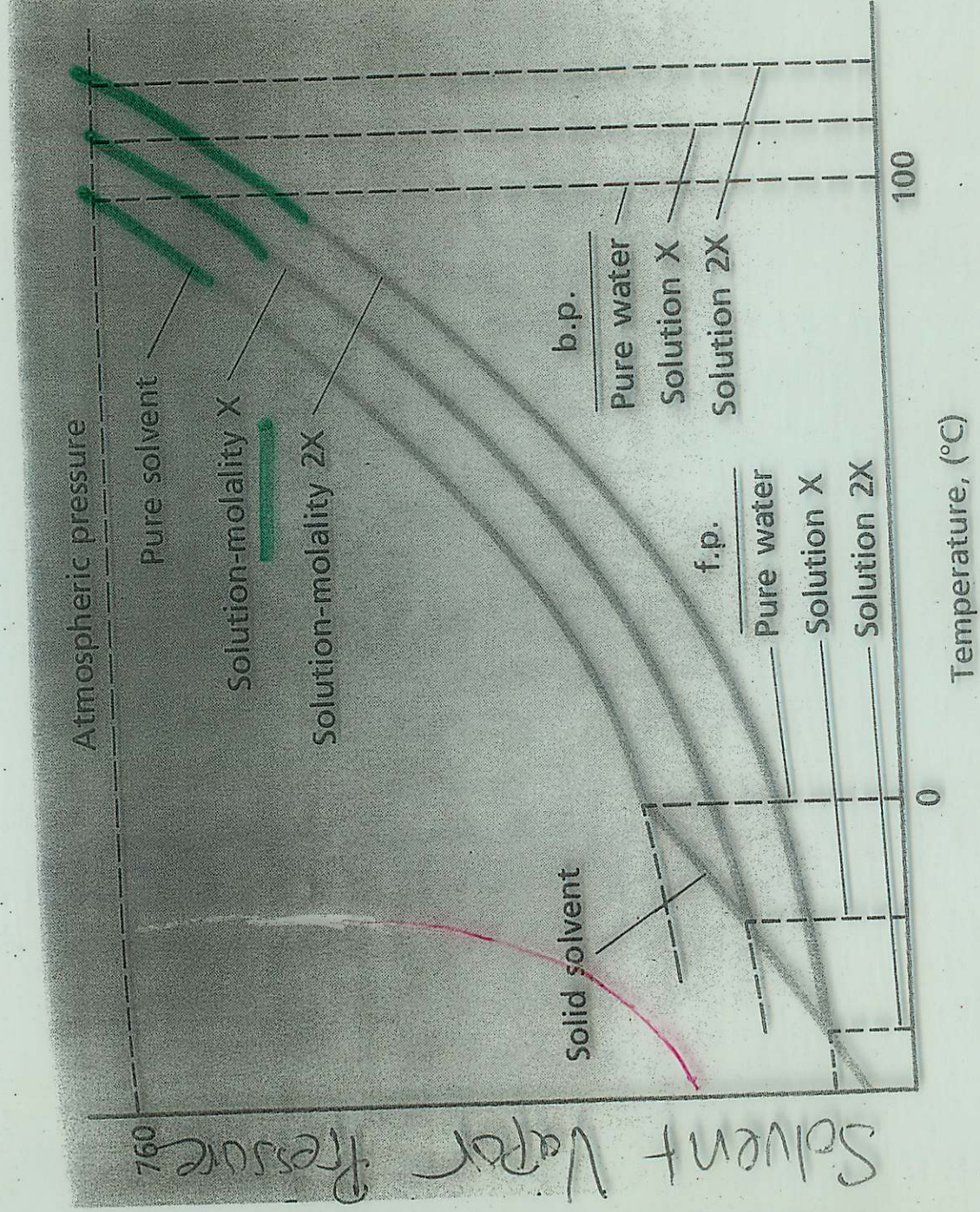
The vapor pressure of water over pure water is greater than the vapor pressure of water over an

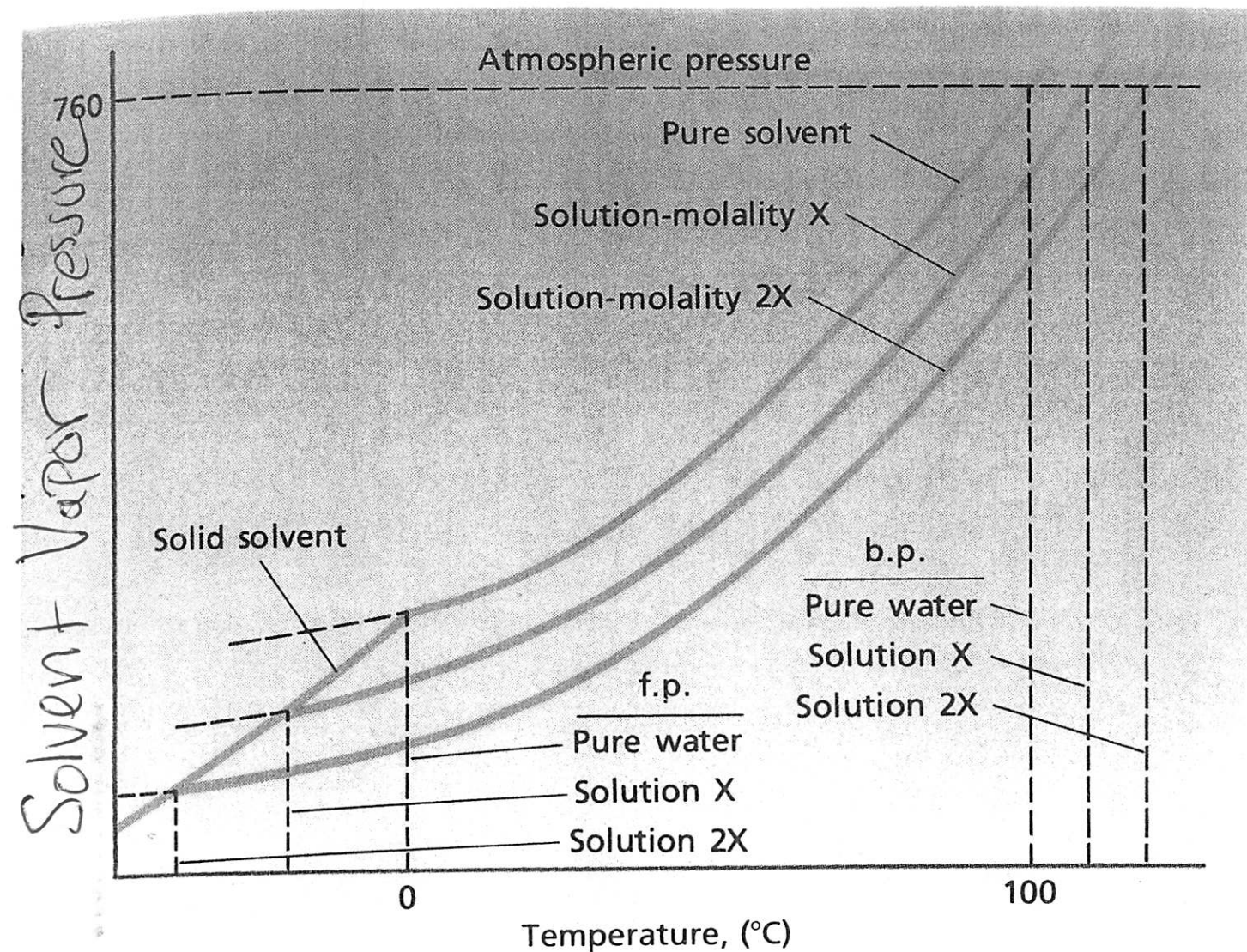
Vapor Pressures of Pure Water and a Water Solution

TEACHING TRANSPARENCY

2002-09-10
10/10/02







For water
temperature
water and 2
depression
are pro
concentr

dependent of their nature is called a **colligative property**. In Figure 14-18, we can see that adding a nonvolatile solute has *lowered* the vapor pressure of the solvent, *lowered* the freezing point of the solution, and *raised* the boiling point of the solution—these are all colligative properties.

In studying colligative properties, solution concentrations are given in molality, which indicates the relative numbers of solute and solvent particles and does not change with temperature. Our discussion of colligative properties in this chapter is limited to dilute solutions of molecular solutes—that is, nonelectrolytes. Solutions of equal molality of any molecular solute in the same solvent have equal vapor-pressure lowering and other colligative properties. As represented by the bottom curve in Figure 14-18, if the molality is doubled, the vapor-pressure lowering, freezing-point depression, and boiling-